Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v15i29.2119

Scientific articles

Guía para evaluación de la Accesibilidad Web Móvil

Guide for the evaluation of Mobile Web Accessibility

Guia para avaliação de acessibilidade à Web móvel

Verónica K. Pagnoni
Ministerio de Educación, Dirección General de Nivel Superior, Argentina
vero_pagnoni@hotmail.com
https://orcid.org/0000-0001-9966-9801

Sonia I. Mariño
Universidad Nacional del Nordeste, Departamento de Informática, Argentina
simarinio@yahoo.com
https://orcid.org/0000-0003-3529-7003

Resumen

Este artículo aborda la evaluación de la Accesibilidad Web (AW) en la tecnología móvil. Se presenta una herramienta de revisión a ser utilizada por un experto para medir de forma integral la AW del contenido Web en dispositivos móviles. La metodología utilizada abarcó tres etapas: estudio de fundamentos teóricos-metodológicos para el abordaje del objeto de estudio, diseñó y validación de una guía de revisión. Teniendo en cuenta el estándar WCAG 2.1, consideraciones propias de la AW móvil y los aspectos evaluables de las herramientas software de validación estudiadas, se diseñó una guía de revisión. La guía diseñada expone el criterio y nivel de conformidad al que corresponde el aspecto, el aspecto a evaluar y la verificación que se debe realizar para el cumplimiento del aspecto. La guía fue validada mediante su aplicación por parte de un experto a una Plataforma Educativa (PE) dirigida a docentes de todos los niveles educativos de cobertura nacional, en el primer trimestre del año 2024. La validación de la propuesta al caso de estudio demuestra que muchos de los aspectos analizados son cumplimentados en las páginas evaluadas, sin embargo, ninguna cumplimenta en su totalidad los principios establecidos en la WCAG 2.1 evaluados. Para finalizar, se

remarca la importancia de utilizar diversas formas y aplicaciones para la medición de la AW móvil, y la relevancia de contar con una herramienta de revisión que ordena y sistematiza el análisis de la AW móvil.

Palabras clave: Accesibilidad Web móvil, herramientas de validación, herramientas de revisión, contenido web, Plataforma Educativa.

Abstract

This article deals the evaluation of Web Accessibility (AW) in mobile technology. A review tool is presented to be used by an expert to comprehensively measure the AW of Web content on mobile devices. The methodology used covered three stages: study of theoretical-methodological foundations for addressing the object of study, design and validation of a review guide. Taking into account the WCAG 2.1 standard, considerations specific to mobile AW and the evaluable aspects of the validation software tools studied, a review guide was designed. The designed guide sets out the criteria and level of conformity to which the aspect corresponds, the aspect to be evaluated and the verification that must be carried out to comply with the aspect. The guide was validated through its application by an expert to an Educational Platform (EP) aimed at teachers of all educational levels with national coverage, in the first quarter of 2024. The validation of the proposal to the case study shows that Many of the aspects analyzed are completed in the evaluated pages, however, none of them fully comply with the principles established in the WCAG 2.1 evaluated. Finally, the importance of using various forms and applications for measuring mobile AW is highlighted, and the relevance of having a review tool that orders and systematizes the analysis of mobile AW.

Keywords: Mobile Web Accessibility, validation tools, review tools, web content, Educational Platform.

Resumo

Este artigo aborda a avaliação da Acessibilidade Web (AW) em tecnologia móvel. Uma ferramenta de revisão é apresentada para ser usada por um especialista para medir de forma abrangente o AW do conteúdo da Web em dispositivos móveis. A metodologia utilizada percorreu três etapas: estudo dos fundamentos teórico-metodológicos para abordagem do objeto de estudo, elaboração e validação de um guia de revisão. Tendo em conta a norma WCAG 2.1, considerações específicas para AW móvel e os aspectos avaliáveis das

Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

ferramentas de software de validação estudadas, foi concebido um guia de revisão. O guia desenhado estabelece os critérios e o nível de conformidade a que corresponde o aspecto, o aspecto a avaliar e a verificação que deve ser realizada para cumprir o aspecto. O guia foi validado através da sua aplicação por um especialista a uma Plataforma Educativa (PE) dirigida a professores de todos os níveis de ensino com abrangência nacional, no primeiro trimestre de 2024. A validação da proposta ao estudo de caso mostra que muitos dos aspectos analisados estão preenchidos nas páginas avaliadas, porém, nenhum deles atende integralmente aos princípios estabelecidos nas WCAG 2.1 avaliadas. Por fim, destaca-se a importância da utilização de diversos formulários e aplicativos para medição de AW móvel, e a relevância de ter uma ferramenta de revisão que ordene e sistematize a análise de AW móvel.

Palavras-chave: Acessibilidade Web Móvel, ferramentas de validação, ferramentas de revisão, conteúdo web, Plataforma Educacional.

Date of Reception: May 2024 **Acceptance Date:** October 2024

Introduction

In a society geared towards modernization and where digital transformation is a constant challenge, it is necessary to have accessible content for everyone and from different media. Web Accessibility (WA) responds to this challenge.

Mobile WI refers to making websites and applications more accessible to users with disabilities when using mobile devices. In this regard, the WAI (Web Accessibility Initiative) addresses accessibility issues for people using a wide range of devices to interact with the web: phones and tablets, digital televisions, accessories such as smartphones, among others (World Wide Web Consortium, sfb).

This work aims to provide a mobile AW review tool that can be used by an expert to comprehensively evaluate, covering different aspects, the AW of Web content on mobile devices.

Theoretical foundations

Mobile devices and disability

According to data published by Statista, in 2022 the number of mobile device users rose to 6.567 billion people worldwide (2024). The International Telecommunication Union (ITU) established in 2023 that 78% of people in the world aged ten years and older have a cell phone, although not all have access to the Internet (UN, 2023).

In 2021, 34.8 million Argentines used smart mobile technology, this represents 1.6 million more users than in 2020. In 2025, the number of people using mobile devices in the country is estimated to be more than 40 million (Statista, 2023).

On the other hand, the World Health Organization (WHO) estimates that 1.3 billion people, 1 in 6 people worldwide, have a disability (2023). The National Study on the Profile of People with Disabilities implemented in urban areas during the months of April and May 2018, revealed that 10.2% of the population aged 6 years and older has some type of disability (National Institute of Statistics and Census [INDEC], 2018).

Following Montoto (2023), an accessible mobile application is defined as one that "all people can perceive, understand and use" (p. 10), regardless of their disabilities or time limitations.

The data presented reveal the increase in the intensive use of mobile devices, and the high number of people who have some disability. It is therefore essential to consider the different disabilities when developing content for mobile technologies. In Torres - Sabroso (2023) disability profiles associated with mobile application users are established:

- Sensory impairment: they have difficulty perceiving the information provided by the mobile device, which can affect data entry. In the case of visually impaired people, it is important to provide alternative information to visual information. Likewise, the size of the text and elements, and the contrast, are essential to ensure accessibility for these users. In the case of people with hearing impairments, it is important to offer visual or haptic alternatives to transmit information.
- Motor disability: users who have difficulty interacting with mobile devices due to a disability that prevents or hinders movement, the application of force or the use of gestures, making difficult for them. Considering these users, simpler input alternatives should be proposed.
- Cognitive disability: These users have difficulty understanding or learning how an application works. To help these users, applications should be created that are simple,

intuitive, consistent and uniform, avoiding convoluted terms, complex instructions or unnecessary navigation.

Mobile Web Accessibility Standards

The W3C has established web accessibility components. These are intended to address different factors on which accessibility depends, and are designed to interact (World Wide Web Consortium, sfa).

The WAI is made up of different groups of guidelines. The "Web Content Accessibility Guidelines" (WCAG) apply to dynamic, multimedia, "mobile" content, etc. There are two standards available: WCAG 2.0 and WCAG 2.1 (World Wide Web Consortium, sfb).

The "Accessibility Guidelines for Content Creation Tools" (ATAG) attempt to make the programs or services that developers use to generate Web content more accessible. The ATAG 2.0 standard is currently published. Regarding the "Accessibility Guidelines for the User Agent" (UAAG), they refer to improving the accessibility of user agents, such as browsers, browser extensions, multimedia players, readers, and others. The UAAG 2.0 is available for use (Muncharaz, 2019).

WC3 has developed technical specifications. These include the "Rich Internet Applications Accessibility" (WAI-ARIA), which provides guidelines for improving the accessibility and interoperability of Web content and applications (Kirkpatrick WAI-ARIA 1.1 is *now* available. It also establishes technical specifications for Web audio and video content, such as "Web Video Text Tracks" (WebVTT) that determine a format for subtitles, textual video descriptions and other metadata that are temporally synchronized with the auditory or visual content; as well as the "Synchronized Text Markup Language" (TTML) that is used to transcode temporally synchronized textual content with older subtitle formats (Muncharaz, 2019).

Likewise, the W3C works on Mobile Accessibility, which refers to making web content more accessible for people with disabilities when using mobile phones; and Cognitive Accessibility to make sites more accessible for people with cognitive and learning disabilities (Lawton-Henry and Brewer, 2019). Although WCAG 2.0 and 2.1 do not directly incorporate techniques to promote mobile AW, WCAG 3.0 (which is currently in its draft version) presents a model that involves a wide variety of needs of users with disabilities. Its scope is much broader and feasible to be used to evaluate: web pages, applications for mobile

technology, browsers, support tools, authoring software and emerging technologies (Montoto, 2023).

The W3C has defined specific aspects of web accessibility on mobile devices according to the principles of the WCAG. They are summarized below (World Wide Web Consortium, 2015):

- Perceptible Principle: small screen size, possibility of enlargement, ability to adjust contrast.
- Principle 2 Operable: Keyboard control, appropriate target size and spacing, simple gestures or alternative functions to complex gestures, easy-to-access button placement.
- Principle 3 Understandable: Possibility of changing the screen orientation, coherent design of different pages that have the same elements, important elements are in a central position and easily accessible, ability to group operable elements that perform the same action.
- Principle 4 Robust: Virtual keyboard configurability, provision of easy data entry methods, support for platform-specific accessibility features.

Mobile Web Accessibility Assessment Tools

The tools studied and selected for testing are briefly described. Regarding the hardware used, only those running under the Android operating system were considered.

Applications for automatic evaluation of mobile AW

- Accessibility Scanner: is a tool that scans an app's user interface to provide recommendations on how to improve the app's accessibility. Accessibility Scanner allows anyone, not just developers, to quickly and easily identify a variety of accessibility improvements (Google Play, 2023); it displays a report consisting of a snapshot where errors are marked and a list of them.
- Accessibility Tester: This application allows you to perform a series of tests involving: order of events, errors, clickable elements, long clickable elements, headers, elements focusable by the screen reader, focused element, testable elements, tested elements, enabled elements, password elements. When one of the tools is selected, the occurrence in the evaluated Web content is graphically marked. Errors

are classified as: size is too small, height is too small, length is too small, missing content description and duplicate content description.

- axe DevTools Mobile: is an accessibility checker for designers, developers, and testers (Deque, 2023). It shows a snapshot of the evaluated content and allows to inspect each element, generates a report of the errors found; and graphs them by classifying them as moderate, serious, and critical. Additionally, it shows the number of failed and approved elements checked.

Semi-automatic mobile AW evaluation applications and native functions

Were considered to access the code of the analyzed Web content. In this case, "Inspect and Edit HTML Live" was studied and used, which has the tools to:

- Inspect Elements: Allows you to access their source code.
- Edit: the source code of the evaluated website.

The application chosen was "Gboard", a virtual keyboard from Google, which allows writing by sliding the finger, voice dictation and handwriting.

Applications and functions belonging to the Android Accessibility Suite (World Wide Web Consortium , 2015) (Torres - Sabroso, 2023) were also taken into account , used to check the mobile Web Accessibility of the evaluated Web content:

- Screen reader
    - TalkBack: application to interact with the device through touch gestures and voice commands.
    - Select to speak: allows you to receive voice feedback, that is, you hear the description of the selected item spoken aloud.
- Screen
    - Text & Display: Some of the options found in this group are:
        - Screen size: allows you to specify the size of the font and other elements.
        - Font Size: Used to adjust the font size.
        - Bold Text – Make the font bold to improve visibility.
        - Color correction: allows you to choose the type of color blindness so that the mobile adapts the colors.
        - Color Inversion: Converts black text on a white screen to white text on a black screen.

- Remove animations: Remove animations, as these may cause dizziness, discomfort or distraction to certain users.
- Large Mouse Pointer - Makes it possible to see a larger mouse pointer when an element accepts input.
- High Contrast Text: Allows you to improve the contrast of your text without changing the background color.

- Extra Dimming: Dims the screen to make it more comfortable to read.
- Dark theme: Darkens the homepage, toolbar, settings, and some other pages.
- Magnification: Increases the content of the screen.

- Interaction controls
  - Accessibility Menu – This is a large menu that helps you operate your device.
  - Action time: allows you to choose the time during which messages referring to the execution of an action are displayed.

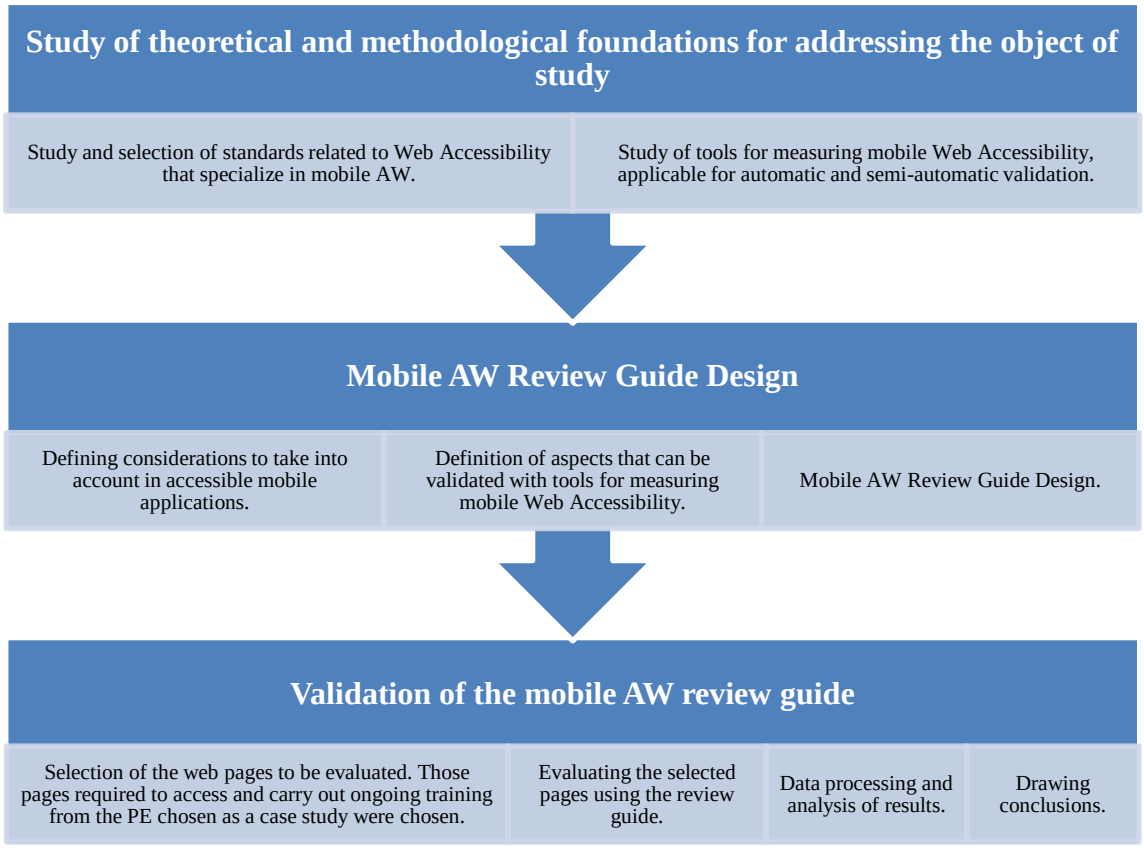
- Subtitles
  - Live Captions: Allows you to automatically caption dialogues on the device.
  - Subtitle preferences: allows you to modify the style and size of the subtitles. It also allows you to change the language of the subtitles.

Likewise, tools specific to the device were used such as: Two and three finger gestures, Up and down gestures, Automatic Rotation.

Methodology

This work is part of an empirical descriptive research. Its objective is to generate an instrument to measure the mobile Web Accessibility of content available on a website. To do so, a mobile AW review guide was designed and applied to an Educational Platform (EP). Figure 1 shows the stages considered.

Figure 1. Stages of work



Source: own elaboration

Results

The results are presented considering the design of the web content review guide using a mobile device and its validation on a national educational platform.

Mobile AW Review Guide Design

The WCAG 2.1 standard was chosen, which is organized into the principles Perceptible, Operable, Understandable and Robust. Each principle is divided into criteria and checkpoints that correspond to different Conformance Levels (A, AA and AAA) depending on the aspects they cover, and are classified from essential to desirable to achieve for the AW, delayed by A, AA, AAA respectively.

Based on the works of Muncharaz (2019), Mariño and Pagnoni (2020), Pagnoni and Mariño (2021), Torres - Sabroso (2023), Montoto, (2023) and Pagnoni and Mariño (2023), mobile AW evaluation tools studied and the characteristics of mobile technology, a review guide was designed. The guide was captured in Table 1 organized by WCAG 2.1 principles;

in column 1 an aspect identifier was placed, in column 2 the criterion and level of conformity to which the aspect corresponds, in column 3 the aspect to be evaluated and in column 4 the verification to be carried out for compliance with the aspect.

Table 1. Mobile AW Review Guide by Principle

Perceptible			
Id	Criterion and level of conformity	Aspect	Verification
1	1.1.1 – A	Non-textual content	The element has a text alternative among its properties.
2	1.2.1 – A	Videos	Animations without audio have a written or audio version. Videos with audio include subtitles for the deaf; text transcription; and audio description.
3	1.2.1 – A	Audios	Audios must have a textual transcription
4	1.3.1 – A	Information and relationships	The information, structure and relationships of the design are established in the code or have a textual alternative (so that they can be interpreted by assistive products).
5	1.3.2 – A	Significant sequence	The meaningful sequence is set in the code (so that they can be interpreted by assistive products).
6	1.3.3 – A	Instructions dependent on sensory characteristics	The instructions provided are not defined only by the sensory properties of the elements.
7	1.3.4 – AA	Changing the screen orientation	Web content adapts correctly when the screen orientation is changed.
8	1.4.1 – A	Use of color	In addition to color, various shapes are used to convey visual information, inform an action, request a response, or denote a visual element.
9	1.4.2 – A	Audio control	Audios that play automatically for more than 3 seconds can be paused or stopped.
10	1.4.3 – AA	Contrast	An appropriate contrast is used between the writings and the database, so that all users can have access.
11	1.4.4 – AA	Text Size	The text font can be enlarged up to 200% without losing information and functionality, using applications or functions of the mobile device.
	Operable		

Id	Criterion and level of conformity	Aspect	Verification
12	2.2.1 – A	Adjustable time	If an action has a time limit to be performed, it can be stopped, adjusted or increased.
13	2.2.2 – A	Pause, stop, hide	Content with animation only longer than 5 seconds can be paused, stopped, or hidden.
14	2.3.1 – A	Flash control	The flashes are lower than the normal flash threshold and red.
15	2.4.2 – A	Page Title	The web page has a descriptive title.
16	2.4.3 – A	Order of focus	The sequence in which components of Web content receive focus preserves their meaning or operation.
17	2.4.4 – A	Purposes of links	The description of a link is sufficiently understandable to facilitate interpretation of the purpose of the link.
18	2.4.6 – AA	Headings and descriptive tags	Headings clearly state the topic of your section. Form element labels are representative of their purpose.
19	2.4.7 – AA	Visible focus	The keyboard focus signal is noticeably noticeable.
20	2.5.1 – A	Touch screen gestures	Web content supports the use of screen gestures.
21	2.5.1 – A	Pointer gestures	Actions that require a multi-point or complex gesture have a way to be performed using a single pointer.
22	2.5.3 – A	Label on the name	Interaction elements have an internal accessible name (so that they can be announced by assistive products).
23	2.5.4 – A	Motion Activation	Functionalities operated by device movement have alternatives in the user interface.
24	2.5.5 - AAA	Small screen size	Web content adjusts to fit the narrow screen size.
25	2.5.5 - AAA	Extension	You can enlarge the amount on the screen.
26	2.5.5 - AAA	Size of interaction elements (target and spacing)	The size and spacing of the interactive elements are suitable to enable their selection.
27	2.5.5 - AAA	Placing buttons where they are easily accessible	The components used for interaction can be accessed even when the device is in different postures.
Understandable			
Id	Criterion and level of conformity	Aspect	Verification

28	3.1.1 – A	Language	The language is set at the code level (so that it can be interpreted by assistive products).
29	3.2.3 – AA	Consistent arrangement	Elements that are located on different pages have to be displayed using an appropriate layout.
30	3.2.4 – AA	Positioning of important elements	The structure of the content facilitates access to important elements.
31	3.2.4 – AA	Grouping of operable elements that perform the same action.	Operable components that refer to the same topic are grouped together.
32	3.3.1 – A	Error Identification	In data entries, the erroneous elements are shown and the source of the error is detailed.
33	3.3.2 – A	Labels and instructions	Form elements must contain corresponding labels and adjacent instructions.
34	3.3.3 – AA	Suggestions for errors	Suggestions are presented in the event of an error.
Robust			
Id	Criterion and level of conformity	Aspect	Verification
35	4.1.1- A	Set the virtual keyboard to the requested input type	Suggests and allows customization of the virtual keyboard considering the type of input requested.
36	4.1.1- A	Provide easy procedures for data entry	It allows information to be entered into a mobile phone in different ways.
37	4.1.1- A	Support for native mobile device applications or functions	Content is compatible with mobile device applications and features.
38	4.1.2 - A	Name, function, value	The name, function and value of the elements on the screens are established in the code (so that assistive products can interpret them).
39	4.1.3 - A	Status messages	Messages that appear on screen for a period of time to communicate the status of the application to the user.

Source: own elaboration

Each aspect will be evaluated as: Compliant (C) in all cases, Moderately (M) does not comply in 25% of cases, Regular (R) does not comply in 75% of cases, No (N) does not comply in any of the cases and Not Applicable (NA) when the aspect cannot be evaluated.

Validation of the mobile AW review guide

In order to validate the review guide presented in 4.1, an Educational Platform aimed at teachers of all educational levels with national coverage was selected as the object of study. This virtual space was validated and analyzed in the first quarter of 2024, using the review guide and a selection of previously indicated automatic and semi-automatic tools. The tests were carried out with the intervention of an expert.

The pages evaluated are defined in Table 2. The selection was based on those most representative for the teacher to access the content and thus carry out the activities aimed at knowing, registering and accessing virtual classes and completing the tasks indicated in the training.

Table 2. Evaluated pages

Designation	Purpose
Page 1	Home page of the post-titles.
Page 2	Login page for postgraduate students.
Page 3	Page where course data is displayed and access to the virtual campus is provided.
Page 4	Page where all virtual classrooms in which the teacher is active as a student are displayed and accessible.
Page 5	Home page of the Virtual Classroom where a module of the postgraduate course that the teacher is taking is developed.

Source: own elaboration

Table 3 shows the results of applying the guide for the evaluation of the 5 selected pages (aspects that did not apply to all pages were omitted). Table 3 is organized by principle: in column 1 is the identifier of the aspect, in column 2 the aspect evaluated, in column 3 the tool(s) used for verification, and the following columns the result of the verification for each page. According to the results obtained in the validation tests, the C, M, R, N and NA ratings explained in the previous section were placed.

Table 3. Results of the implementation of the mobile AW review guide

Perceptible							
Id	Aspect	Verification tool	Page 1	Page 2	Page 3	Page 4	Page 5
1	Non-textual content	- Navigation and observation	C	C	C	C	C
4	Information and relationships	- Inspect and Edit HTML Live - axe DevTools Mobile (Clickable control that was not marked as important, Accessibility element with multiple embedded active controls, Control with part of text not visible, Text marked as not important)	M	C	R	R	R
5	Significant sequence	- Accessibility Tester (Order of elements) - TalkBack	C	C	C	C	C
7	Changing the screen orientation	- Auto Rotation Function	C	C	C	C	C
8	Use of color	- Navigation and observation	C	C	C	C	C
10	Contrast	- Accessibility Scanner (Contrast) - ax DevTools Mobile (Low Contrast)	M	C	C	R	R
11	Text Size	- Text Size Function - Two-finger gestures	C	C	C	C	C
Operable							
Id	Aspect	Verification tool	Page 1	Page 2	Page 3	Page 4	Page 5
15	Page Title	- Inspect and Edit HTML Live	N	N	N	N	N
16	Order of focus	- Accessibility Tester (Order of elements)	C	C	C	C	C

17	Purposes of links	- Navigation and observation	R	M	R	M	M
18	Headings and descriptive tags	- Accessibility Tester (Not marked as headers) - TalkBack	C	C	C	C	C
19	Visible focus	- Navigation and observation	R	C	R	C	C
20	Touch screen gestures	- Two and three finger gestures - Up and down gestures	C	C	C	C	C
22	Label on the name	- Inspect and Edit HTML Live - TalkBack	R	M	R	R	R
24	Small screen size	- Screen Size Function - Navigation and observation	N	N	N	N	N
25	Extension	- Two-finger gesture - Magnification function	C	C	C	C	C
26	Size of interaction elements	- Accessibility Tester - Accessibility Scanner - axe DevTools Mobile (size/width/height is too small)	N	N	N	N	N
27	Placing buttons where they are easily accessible	- axe DevTools Mobile (integrated active controls)	M	M	R	R	R
Understandable							
Id	Aspect	Verification tool	Page 1	Page 2	Page 3	Page 4	Page 5
28	Language	- Inspect and Edit HTML Live	C	C	C	C	C
29	Consistent arrangement	- Navigation and observation	C	C	C	C	C
30	Positioning of important elements	- Inspect and Edit HTML Live - axe DevTools Mobile (Clickable control that was not marked as	M	M	R	R	R

		important, Accessibility element with multiple embedded active controls, Control with part of Text not visible, Text marked as not important)					
32	Error Identification	- Navigation and observation	NA	C	NA	NA	NA
33	Labels and instructions	- Inspect and Edit HTML Live - ax DevTools Mobile (Attached tag missing)	M	M	M	M	M
34	Suggestions for errors	- Navigation and observation	NA	C	NA	NA	NA
Robust							
Id	Aspect	Verification tool	Page 1	Page 2	Page 3	Page 4	Page 5
35	Set the virtual keyboard to the requested input type	- TalkBack - Voice dictation function - Gboard	NA	C	NA	NA	NA
36	Provide easy procedures for data entry	- TalkBack - Voice dictation function - Gboard	NA	C	NA	NA	NA
37	Support for native mobile device applications or functions	- Content changes: Magnification, Gestures, Screen rotation, Color correction, Color inversion, Select to speak - Content does not change: Bold text, Text size, Display size, High contrast text, Dark theme.	M	M	M	M	M
38	Name, function, value	- Inspect and Edit HTML Live - TalkBack - axe DevTools Mobile	M	M	M	M	M
39	Status messages	- Inspect and Edit HTML Live	NA	C	NA	NA	NA

Source: own elaboration

In the validation of the AW of the Educational Platform using a mobile device, it was determined that:

- Perceptible Principle: Of the 7 aspects evaluated, 5 of them are fulfilled on all pages, and two of them are not fulfilled on all pages. One of the aspects that is not fulfilled is "Information and relationships" – it is regularly fulfilled on pages 3, 4 and 5, and to a certain extent on page 1 – constituting a major accessibility barrier because, without the necessary information, the appropriate structure and the corresponding relationships, users with sensory or motor disabilities will not be able to access the Web content when using a support application, and those with cognitive disabilities will have many difficulties in understanding it. Furthermore, there are shortcomings in terms of "Contrast" – which is regularly completed on pages 4 and 5, and to a limited extent on page 1 – which means that if the tone of the writing does not contrast sufficiently with the base, many users with sensory disabilities, especially those with some type of visual disability, would be unable to read them or would do so with great effort.
- Operable Principle: Of the 11 aspects evaluated, 4 of them are fulfilled on all pages, and 7 are not fulfilled in their entirety on the validated pages. It was confirmed by analyzing the code that the aspects "Title of the page" –which is not fulfilled on any page– "Purposes of the links" and "Label in the name" –which are fulfilled to a moderate and regular extent on the pages– are not representative of the Web content, which represents a huge obstacle to the AW because people with cognitive disabilities will have difficulty understanding it and the help tools will provide unclear information to users with sensory and motor disabilities. Likewise, the "Visible focus" aspect –which is not fulfilled on all the elements on pages 2 and 3– represents an indispensable characteristic so that users with sensory difficulties, such as those with partial or total vision problems, can navigate through the Web content, as well as users with motor disabilities. Problems have also been detected when evaluating the aspects "Small screen size", because the content does not adjust when the screen is enlarged, which is not fulfilled in any of the pages evaluated. Other aspects analyzed are "Size of interaction elements" and "Placement of buttons where they are easily accessible" –which are not fulfilled in any of the pages evaluated– which are

related to the size and location that the elements with functionality must have to be accessible, this means an enormous barrier to the AW of any user.

- Principle Understandable: Of the 5 aspects analyzed, 3 of them are fulfilled on all pages, and 2 are not fulfilled on all pages. The aspects "Positioning of important elements" –which is fulfilled to a moderate extent on pages 1 and 2 and regularly on pages 3, 4 and 5– and "Labels and instructions" –which is fulfilled to a moderate extent on all pages– have a negative impact on the AW, especially for people with sensory and motor disabilities, who use assistive applications to access Web content.
- Robust Principle: It was determined that, out of 5 aspects considered in the guide, 3 of them are not applied in 4 of 5 pages, and only 2 are applied to a certain extent in all the pages of the sample. The latter correspond to the aspects "Compatibility with applications or native functions of the device" and "Name, function, value".

Discussions

In the design of this guide, Muncharaz (2019) was considered regarding the ATAG and UAAG guidelines, which refer to achieving more accessible services and user agents. The contributions of Torres - Sabroso (2023) were also taken into account, who mentions mobile applications in relation to disabilities: sensory, motor and cognitive. Likewise, Montoto (2023) was taken into consideration regarding some of the native applications and functions for the review of the mobile AW, and WCAG criteria referring to aspects that most affect people with disabilities when they access web content through a mobile device.

The review of the mobile AW presented in Mariño and Pagnoni (2020) was also taken into account, where tools such as: Accessibility Scanner, Check My Colour and native functions are used: Magnification gestures, High contrast font, Invert colours, Colour correction, Font size, Screen orientation, TalkBack; with which they verify various aspects of the mobile AW related to the disabilities mentioned. As a contribution to this work, it can be mentioned that the number and diversity of tools used to evaluate the mobile AW is much greater, the applications were added: Accessibility Tester, axe DevTools Mobile, Inspect and Edit HTML Live and Gboard; and the native functions: Two-finger and three-finger gestures, Up and down gestures, Screen size, Bold text, High contrast text, Dark theme, Voice dictation and Select to speak. Thus improving the review, contrasting and complementing the results obtained when using them.

On the other hand, the manual review guide for web content presented in Pagnoni and Mariño (2021) was taken as a basis. In its second part, it proposes the evaluation of different aspects through questions that the user must answer by browsing the web space. Also, the proposal presented in Pagnoni and Mariño (2023) was considered, in which a guide for manual review to be used by a computer expert is proposed. In this case, other aspects not considered in these works were added, especially those related to the characteristics of mobile devices: small screen size, possibility of enlargement, adequate size of the lens and spacing, simple gestures, possibility of changing the orientation of the screen, important elements easy to access, possibility of configuring the virtual keyboard, support for the accessibility features of the platform, among others. Additionally, a more complete review was proposed based on the use of multiple tools, in addition to observation and navigation.

In summary, the work presented in this article represents a major contribution and is different from previous works. First, due to the completeness of the review, given the different forms and tools used. Second, the incorporation of specific aspects of mobile technology and considering the established standards of mobile AW, into a review guide that allows the task of evaluating mobile Web content to be carried out in an orderly, systematic and comprehensive manner.

The limitation of this work lies in the lack of access to the site to apply the changes derived from this analysis.

Conclusions

This article proposes the design, construction and validation of an AW evaluation guide for mobile devices. This guide is a powerful tool to be used by developers to improve the AW of their content accessed from mobile devices. It covers a range of aspects belonging to the different principles and Conformance Levels specified in the WCAG 2.1 standard. The characteristics of mobile devices were added, which allows for a comprehensive and complete validation of the AW of Web content in its mobile version.

As expressed in the results, many of the aspects analysed are fulfilled in the evaluated pages. However, no page complies in its entirety with the principles established in WCAG 2.1 evaluated; there are many aspects belonging to Conformity Levels A, AA and AAA that are not satisfactorily specified.

Future lines of research

The evaluation findings provide an approximation of the quality criteria associated with AW that should be corrected in order to contribute to improving the user experience.

In future interventions, it is planned to carry out other experiments modifying access with other devices or with other support tools on the evaluated site. The qualitative and quantitative findings would allow for improving studies and planning interventions with the aim of reducing the potential digital gap that implicitly affects Web Accessibility problems.

Acknowledgements

The article corresponds to a Master's thesis, and is part of the Research Group Information Systems and IT: Models, Methods and Tools, accredited by the General Secretariat of Science and Technology of UNNE.

References

Deque. (2023). Axe Accessibility Testing Tool. https://www.deque.com/axe/

Google. (2024). Descripción general de la accesibilidad de Android. https://support.google.com/accessibility/android/answer/6006564?hl=es-419

Google Play. (2023). Accessibility Scanner. https://play.google.com/store/apps/details?id=com.google.android.apps.accessibility.auditor&hl=en_US

Instituto Nacional de Estadística y Censos (INDEC). (2018). *Estudio nacional sobre el perfil de las personas con discapacidad. Resultados definitivos 2018*. Ciudad Autónoma de Buenos Aires, Argentina: Agencia Nacional de Discapacidad. https://www.indec.gob.ar/ftp/cuadros/poblacion/estudio_discapacidad_12_18.pdf

Kirkpatrick, A., Connor, J. O., Campbell, A. y Cooper, M. (2017). Aplicaciones de Internet enriquecidas accesibles (WAI-ARIA) 1.1. https://www.w3.org/TR/wai-aria-1.1/

Lawton-Henry, S. y Brewer, J. (2019). Acerca del W3C WAI. https://www.w3.org/WAI/about/#world-wide-Web-consortium-w3c-Web-accessibility-initiative-wai

Mariño, S. y Pagnoni, V. (2020). Accesibilidad Web en dispositivos móviles. Evaluación de un portal educativo de alcance nacional. *International Journal of Educational Research and Innovation (IJERI)*, 13, 208-225. (ISSN: 2386-4303).

Montoto, O. C. (2023). *Guía: Aplicaciones móviles accesibles*. España: Real Patronato sobre Discapacidad y Ministerio de Derechos Sociales y Agenda 2030.

Muncharaz, C. (marzo de 2019). Resumen de los estándares de accesibilidad de W3C. https://www.w3.org/WAI/standards-guidelines/es

Organización de las Naciones Unidas (ONU). (diciembre de 2023). Más del 75% de la población mundial tiene un teléfono celular y más del 65% usa el Internet. https://news.un.org/es/story/2023/12/1526712#:~:text=El%2078%25%20de%20la%20poblaci%C3%B3n,Internacional%20de%20Telecomunicaciones%20(UI).

Organización Mundial de la Salud (OMS). (marzo de 2023). *Discapacidad. Datos y cifras.* https://www.who.int/es/news-room/fact-sheets/detail/disability-and-health

Pagnoni, V. K. y Mariño, S. I. (2021). *Una guía de Accesibilidad Web para portales educativos. La revisión de usuarios.* Congreso Argentino de Ciencias de la Computación (CACIC). Argentina.

Pagnoni, V. K. y Mariño, S. I. (2023). Accesibilidad Web centrada en revisiones manuales. Estudio de un EVA de formación docente continua. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, 36, 51-59.

Statista. (octubre de 2023). Argentina: número de usuarios de móviles inteligentes 2015-2026. https://es.statista.com/estadisticas/598527/numero-de-usuarios-de-moviles-en-argentina/

Statista. (enero de 2024). Industria mundial de smartphones - Datos estadísticos. https://es.statista.com/temas/10145/industria-y-consumo-mundial-de-smartphones/#topicOverview

Torres-Sabroso, Sandra (Coord.) (2023). *Guía de accesibilidad de Aplicaciones Móviles (Apps) v.3.* España: Secretaría General de Administración Digital. Ministerio de Asuntos Económicos y Transformación Digital.

World Wide Web Consortium. (s.f.a). Accesibilidad Móvil en el W3C. https://www.w3.org/WAI/standards-guidelines/mobile/es

World Wide Web Consortium. (s.f.b). Web Accessibility Initiative. https://www.w3.org/WAI/

World Wide Web Consortium. (2015). Accesibilidad móvil: cómo se aplican WCAG 2.0 y otras pautas de W3C WAI al móvil. https://www.w3.org/TR/mobile-accessibility-mapping/

Contribution Role	Author(s)
Conceptualization	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Methodology	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Software	NOT APPLICABLE
Validation	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Formal Analysis	NOT APPLICABLE
Investigation	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Resources	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Data curation	NOT APPLICABLE
Writing - Preparing the original draft	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Writing - Review and editing	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Display	Veronica K. Pagnoni ; Sonia I. Mariño “same”
Supervision	NOT APPLICABLE
Project Management	NOT APPLICABLE
Acquisition of funds	NOT APPLICABLE